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TREATMENT OF LAUNDROMAT WASTES

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Massachusetts Department of Public Health
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Treatment of Laundromat Wastes

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Treatment of Laundromat Wastes by Coagulation with Alum and Adsorption through Activated Carbon

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SUMMARY

The process evolved here for the treatment of laundromat waste has proven effective, dependable, and economical. Coagulation and clarification with alum and lime followed by carbon filtration removed nearly all of the ABS. Filtration of the clarified liquor through a column of granular activated carbon proved much more effective, economical, and convenient than addition of powdered carbon with the coagulating chemicals.

Although much of the present furor concerning laundromat wastes centers around problems associated with the ABS concentration, the process removed considerably more organic matter than ABS alone. COD, BOD, and phosphate removals were respectively 86, 87, and 98%, and coliform removals approached 100% at pH values greater than 11. These results seem significant since it is doubtful that future replacement of "hard" ABS with other detergents would of itself justify curtailment of laundromat waste treatment.

Coagulation with 250 mg/L alum and 410 mg/L lime (at pH values over 11) produced a rapidly settling floc with high resistance to scour, unlike the fluffy alum floc produced at low pH values. Although alum is present as the aluminate ion at high pH values, the process proved much less effective without it. Laboratory tests showed that somewhat lower alum doses might also produce good results, but the concentrations recommended here resulted in an exceedingly clear liquor and a very low suspended solids loading on the sand filter and carbon column.

Granular Pitt Carbon, 8 x 30 mesh, proved to be highly adsorptive with both a higher efficiency and greater capacity than other carbons used.

CHEMICAL TREATMENT OF LAUNDROMAT WASTES - PHASE I

INTRODUCTION

This is a report on the various investigations that were made by the Water Pollution Laboratory on the treatment of laundromat waste water. We became involved with this study when we were requested to observe a new installation of a treatment plant by the Bruner Clear Corporation at the Village Coin-Op Laundromat in Auburn, Mass. The flow diagram of this unit is shown in Fig. 1.

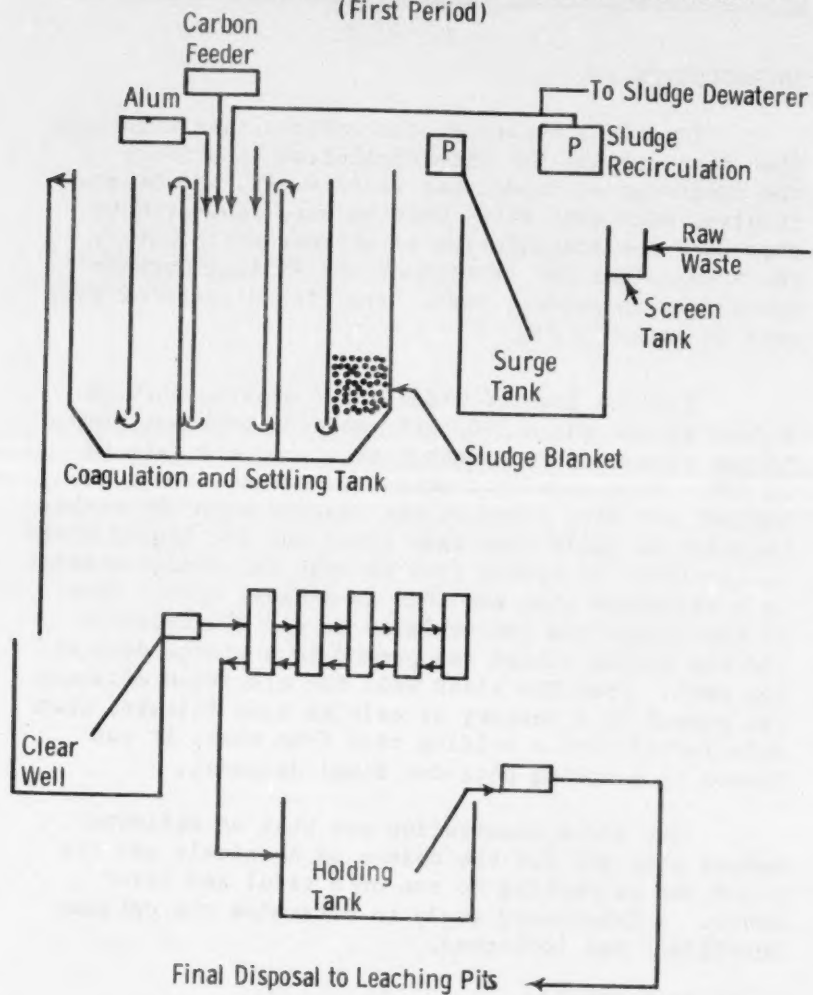
The raw laundry waste after passing through a fine screen and a 5000 gal. holding tank was pumped to the center of the reactor at a constant rate of 10 GPM. Alum, powdered activated carbon, and a coagulant aid were added to the reactor with the waste. Coagulation would then take place and the liquid would be clarified by upward flow through the sludge blanket to a collector pipe and then to a clear well. Some of the sludge was recirculated to aid flocculation and the excess sludge was pumped to a sludge dewatering tank. From the clear well the clarified effluent was pumped to a battery of calcite sand filters, then chlorinated into a holding tank from where it was pumped to leaching pits for final disposal.

Our first observation was that no definite values were set for the dosage of chemicals and the plant was attempting to run on a trial and error basis. A laboratory study to determine the optimum conditions was indicated.

LABORATORY STUDIES

We therefore inaugurated a laboratory investigation to determine optimum conditions and parameters for the complete treatment of laundromat wastes by chemical means, using alum and activated carbon. Special attention was given to the removal of detergents as measured by ABS concentrations. Fresh waste for this study was supplied weekly from the Village Coin-Op Laundromat.

Fig. 1 - FLOW DIAGRAM OF LAUNDROMAT WASTE TREATMENT
(First Period)



The first phase of our investigation was divided into five parts:

- I. Determination of Optimum Alum Dose
- II. Relative Importance of Alum Dose and pH
- III. Flocculation with Alum and Activated Carbon

- IV. Alum Flocculation followed by Gravity Filtration through Activated Carbon
- V. Alum Flocculation followed by a series of Carbon Columns

I. Determination of Optimum Alum Dose

Over a period of two months, six different raw waste samples from the Village Coin-Op were treated in the laboratory with various concentrations of alum. The samples were flocculated and settled in the usual "jar-test" procedure. The results are summarized as averages in Table I.

Table I. -- Effect of Alum on the Removal of Pollutants from Laundromat Waste

Alum Dose mg/L	ABS Remaining mg/L	COD Remaining mg/L	BOD Remaining mg/L	pH	Alk mg/L
Raw - 0	65	580	215	7.1	158
400	50	394	132	6.3	55
600	20	170	46	5.1	7
800	15	143	41	4.5	0
1000	12	128	38	4.2	0

Although an alum dose of 600 mg/L appeared to be marginally effective for most samples, 800 mg/L was considered to be the most practical dose for the following reasons:

1. A consistently clear supernatant liquor after settling (600 mg/L did not always appear to accomplish this).
2. A margin of safety for increases in waste strength.
3. Higher doses did not materially increase treatment efficiency, and would either increase residual alum concentration or require alkalinity addition (and produce more sludge).

II. Relative Importance of Alum Dose and pH

Preliminary studies suggested that for an individual laundromat sample, the optimum alum dose appeared to be that dose which just "used up" the alkalinity, producing a pH range of 4.3 - 4.6. Therefore, a simple laboratory experiment was conducted to determine if treatment accomplished by the optimum dose of alum alone could be equalled by lower alum doses and pH adjustment down to 4.3 with sulfuric acid. The results are shown in Table II.

Table II. -- Importance of Flocculation pH

Chemical Addition	pH	ABS Remaining mg/L	COD Remaining mg/L	BOD Remaining mg/L
0 (Raw Waste)	7.2	64	582	203
400 mg/L Alum	5.7	50	368	129
" " " + H ₂ SO ₄	4.4	50	323	102
500 mg/L Alum	5.1	45	358	103
" " " + H ₂ SO ₄	4.4	22	136	46
600 mg/L Alum	4.5	15	116	44
800 mg/L Alum	4.1	14	116	44

As implied in Table II, 600 mg/L of alum was the most efficient dose for this particular waste sample. Flocculation was excellent and settling was rapid, producing a clear supernatant liquor with COD and ABS removals of 80 and 77% respectively. It can also be noted that 600 mg/L of alum lowered the pH to 4.5.

The importance of flocculation pH is dramatically shown in Table II. A dose of 500 mg/L of alum resulted in a pH of 5.1 (alkalinity $\approx$ 10 mg/L), poor flocculation and settling, and inadequate treatment. The same dose of alum plus a few drops of dilute sulfuric acid, on the other hand, lowered the pH to 4.4

producing good flocculation and settling with ABS and COD removals of 67 and 77% respectively as compared to 30 and 38% with 500 mg/L alum alone.

The natural companion experiment to the preceding study involved the addition of a constant alum dose of 800 mg/L to a series of raw waste samples containing increasing concentrations of alkalinity. Sodium carbonate solution was added to a series of beakers containing raw waste, increasing the alkalinity by 50, 100, 150, 200, and 300 mg/L. An alum dose of 800 mg/L was then added to each of the samples and flocculated by the jar test procedure. The precipitate was allowed to settle and the supernatant was analyzed for ABS and COD remaining. The results are summarized in Table III.

Table III. -- Importance of Raw Waste Alkalinity on Alum Flocculation of Laundromat Waste

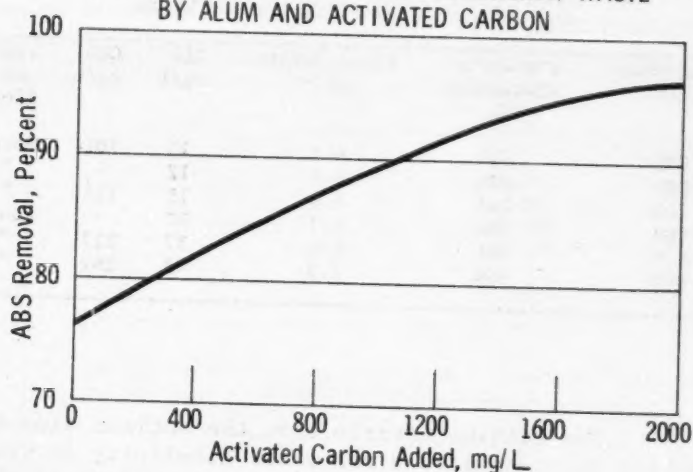
Alum added mg/L	Raw Waste Alkalinity mg/L	Flocculation pH	ABS mg/L	COD mg/L	Type of Floc
800	144	4.1	13	101	Good
800	194	4.4	12	-	"
800	244	4.8	15	116	"
800	294	6.3	37	-	Poor
800	344	6.6	37	217	"
800	444	7.3	43	262	"

The results clearly show the optimum alum dose to be a function of the raw waste alkalinity as well as the raw waste strength. A flocculation pH of about 4.3 - 4.6 was indicated for the best treatment of the laundromat waste used in this study. Alum doses higher than optimum did not adversely affect flocculation or treatment, but naturally resulted in excessive residual alum concentrations and "post-precipitation" problems. It will be noted in Table III that 800 mg/L of alum was effective in the range of 144 to 244 mg/L raw waste alkalinity.

III. Flocculation with Alum and Activated Carbon

In part I, 800 mg/L of alum was established as the best practical dose for the flocculation of Village Laundromat waste. In the following study, 800 mg/L of alum plus various doses of activated carbon were added to several samples of waste to determine the removal effect of carbon on ABS. In the jar-test procedure, powdered "Nuchar" was added first and followed immediately by alum. Although the three raw waste samples used in this study varied in ABS concentration, the percent ABS removal as a function of carbon added produced a reasonably consistent relationship, as shown in figure 2. A dose of 800 mg/L of alum alone removed an average of 78% ABS, while 800 mg/L of alum plus 2000 mg/L activated carbon removed approximately 97% ABS.

Fig. 2 - REMOVAL OF ABS FROM LAUNDROMAT WASTE
BY ALUM AND ACTIVATED CARBON



PERFORMANCE OF WASTE TREATMENT PLANT - FIRST TWO PERIODS

During the initial phas of our study, weekly samples were submitted from the Village Coin-Op Treatment Plant. During the first 5 week period, the plant

was operated as originally designed, using alum, coagulant aid, powdered activated carbon in the reactor tank, followed by filtration through calcite sand filters. Considerable difficulty was encountered with the sand filters and they were by-passed during the second 5 week period.

Table IV shows the results of the analysis of the waste and treated effluents during these two periods. It will be noted that the treatment improved slightly during the second period as the operator became more familiar with the operation of the unit. The chemical doses were 800 mg/L of alum and approximately 400 mg/L of carbon. The removals effected closely paralleled the laboratory results.

Table IV. -- PERFORMANCE OF LAUNDROMAT
WASTE TREATMENT PLANT

First Period ¹				
	Influent	Coagulated	Effluent	Percent Reduction
pH	7.1	4.4	5.4	-
ABS	62	21	20	68
BOD	209	21	23	89
COD	541	149	137	75
Suspended Solids	124	39	74	40

Second Period ²			
	Influent	Coagulated (Eff)	Percent Reduction
pH	7.3	4.2	
ABS	65	11	83
BOD	263	25	90
COD	646	132	79
Suspended Solids	187	33	82

¹ 5 weeks, 5 sets of samples

² 5 weeks, 6 sets of samples

IV. Alum Flocculation followed by Gravity Filtration through Activated Carbon

The laboratory studies thus far indicated that in order to effect significant removals of ABS with powdered activated carbon about 2000 mg/L of carbon would be required. It was apparent that this would be impractical and uneconomical. The handling of the powdered activated carbon proved to be a nuisance at the laundromat and created a hazardous and annoying atmosphere in the small confines of the treatment plant. It was felt, therefore, that it might be more convenient, less dusty, more efficient, and less expensive to flocculate the raw waste with alum alone, followed by gravity filtration of the clarified liquor through a column of granular activated carbon.

Accordingly, 59 grams of carbon were placed in a 1.5 inch diameter glass tube, making a column 7 inches deep. The column was supported by glass wool and 1 inch of gravel, and its surface was covered with glass wool. The carbon was not allowed to dry out by maintaining a liquid level above the carbon surface at all times.

Table V. -- Effect of Carbon Filtration on Coagulated Laundromat Waste

Volume liters	ABS, mg/L		COD, mg/L	
	Influent	Effluent	Influent	Effluent
0 - 20	8.2	3.1	164	90
21 - 40	7.3	3.9	160	95
41 - 60	7.3	4.6	137	100
61 - 80	7.3	3.8	137	100
81 - 100	7.3	3.6	137	100
101 - 120	10.0	4.2	136	95
121 - 140	10.0	5.5	136	96
141 - 160	11.0	6.2	131	84
161 - 180	11.0	8.5	131	89
181 - 200	9.6	7.4	130	86
Average	8.9	5.1	140	94

In order to obtain an estimate of the carbon's adsorptive capacity, a total of 200 liters of coagulated and clarified laundromat waste was passed through this column over a period of several weeks. Influent and effluent samples were analyzed periodically for COD and ABS concentrations. There was some experimentation with flow rates, but for the most part the rate was maintained at 0.5 gal/ft²/min. (22 ml./min.). The results are summarized in Table V.

The difference between influent and effluent COD concentrations indicates that a significant reduction in organic material was achieved as well as removal of ABS. Effluent ABS concentration, however, was the most sensitive indicator of loss in adsorptive capacity. After 100 - 120 liters of coagulated waste had been filtered the adsorptivity of the carbon column for ABS (though not COD) began to "fade."

If the carbon filter were followed by another similar filter, the ABS and COD would be further reduced. In this way the most economic use of the carbon would be obtained because the first filter could then be used until it was completely exhausted. Furthermore, filter replacement could be accomplished without interrupting the operation.

V. Carbon Filters in Series

With the partially exhausted filter of Part IV still in service as a "roughing" filter, two additional

Table VI. -- Serial Carbon Filtration of Coagulated Waste

	ABS	COD	BOD
Raw Waste	64	590	220
Alum Coagulated Waste	8.6	137	30
Effluent Column #1	6.6	88	15
Effluent Column #2	2.5	54	6
Effluent Column #3	0.1	39	1

Note: Results are in mg. per liter of substance remaining

columns of fresh granular carbon were placed in series following the first. They were of similar size and construction to the first.

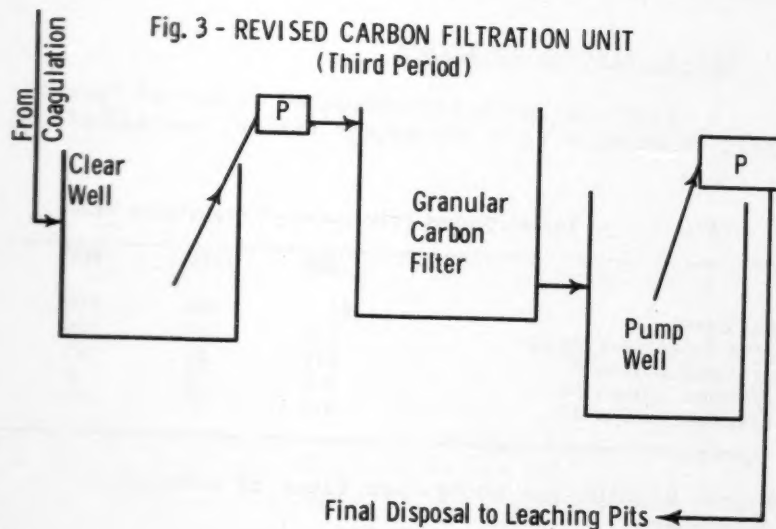
Sixteen liters of coagulated laundromat waste were passed through the three carbon columns in series. The results are summarized in Table VI.

Alum flocculation followed by serial filtration through three columns of granular activated carbon removed over 99% of ABS and BOD and 93% of the COD.

PERFORMANCE OF LAUNDROMAT WASTE TREATMENT PLANT - THIRD PERIOD

At the same time that the laboratory studies were being conducted as outlined in Parts IV and V, the treatment plant made changes to coincide with the laboratory findings.

The original sand filters were eliminated, because the time consumed in the maintenance was not commensurate with the negligible benefits obtained. Difficulties experienced in operating the sludge dewaterer showed that it was more feasible to simply pump

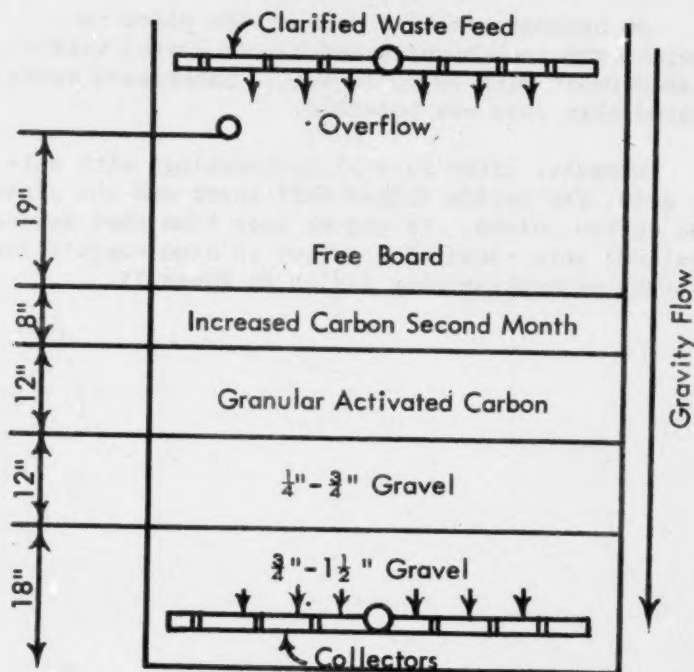


the excess sludge periodically from the coagulation and clarifying tank into a tank truck for disposal by burial.

The revised system is shown in Figure 3. Since basically no change was made in the first part of the process except for the chemical doses, only the latter part which follows the coagulation and clarification unit is shown. The original unused sludge dewatering tank was converted to a gravity flow carbon filter and a cross-section is shown in Figure 4. This filter had an area of 20 square feet, which affords, filter rate of 0.5 GPM/sq.ft. This rate was identical to that used in the laboratory columns.

The results of analyses of the Waste Treatment Plant during the third period are shown in Table VII.

Fig. 4 - SECTION THROUGH FILTER
(Third Period)



The results reported are averages of 12 sets of samples over an 8 week period.

Table VII. -- Performance of Laundromat Waste Treatment Plant
Third Period *

	Influent	Coagulated	Effluent	Percent Reduction
pH	7.2	4.1	4.9	
ABS	73	11	5.2	93
BOD	240	45	21	91
COD	630	130	74	88

* 8 weeks, 12 sets of samples

The average percent reductions effected by this system were 93%, 91% and 88% for ABS, BOD, and COD respectively. The average effluent concentration of 5.2 (range, 1.8 - 7.3) was still considered to be too high based on the PHS standard for drinking water of 0.5 mg/L.

An attempt was also made at the plant to regenerate the carbon which had become coated with a grayish deposit with sulfuric acid. Laboratory tests indicated that this was possible.

However, after several backwashings with sulfuric acid, the entire filter fell apart and the plant had no carbon column. It was at this time that several suggestions were received relative to alum coagulation and carbon adsorption that led us to Phase II.

CHEMICAL TREATMENT OF LAUNDROMAT WASTES - PHASE II

COAGULATION WITH ALUM AND LIME

In phase I, 800 mg/L of alum was found to be the optimum dose when alum alone was used as the coagulant. It was suggested to us that much lower alum concentrations could be used in conjunction with lime at a pH of 11.4.

Accordingly, laboratory studies were initiated to determine if the waste could be coagulated at this pH. The results of a typical jar test are shown in Table VIII.

Table VIII. -- Coagulation of Laundromat Waste with Alum and Lime (to pH 11.4)

Alum Added	ABS mg/L	Remarks
0	68	Raw Waste
0	32	Turbid (Lime added to pH 11.4)
50	26	" "
100	23	Sl. turbid "
150	22	" "
200	20	Clear "
250	18	Very clear "
300	19	" "

The recommended dosages based on laboratory data and observations were 250 mg/L of alum plus lime to pH 11.4 (410 mg/L). This represented a greater than three-fold saving in alum, while lower doses sometimes resulted in a turbid supernatant which would plug the carbon filter. The greatest advantage of the use of lime with alum at high pH was the rapid settling floc which resulted. The rate of flow through the reactor at the Village Coin-Op could be increased from 10 GPM to 20 GPM. This would enable the treatment plant to take care of peak flows without any danger of flooding the surge tank.

The average coagulation results of 8 samples from the prototype (Village Coin-Op Laundromat in

Auburn, Mass.) taken over a two month period are summarized in Table IX.

Table IX. -- Alum-Lime Coagulation (Village Coin-Op)

	Raw	Treated
ABS	74	14
COD	670	158
BOD	185	46
pH	8.5	11.3
Alk. Phth.	22	147
Alk. Total	288	231
Susp. Solids	367	49
250 mg/L alum plus 410 mg/L lime		

USE OF GRANULAR ACTIVATED CARBON MADE FROM COAL

The coagulated laundromat waste was applied to granular activated carbon filters. The small laboratory filters were 1.5 inches in diameter each containing a carbon column 6 inches deep. The clear coagulated waste (at pH 11.4) was passed through the column at a rate of approximately 1 liter per hour. The major purpose of this test was to compare activated carbon from coal (Pitt 8 x 30) with that used in the first

Table X. -- Comparison of Two Types of Activated Carbon

Volume Filtered, liters	ABS Concentration - mg/L			
	Type I Act. Carbon Effluent Filter			Type II Act. Carbon Single Filter
	No. 1	No. 2	No. 3	
0 - 20	10	5.6	1.8	0.50
20 - 40	12	6.8	3.2	0.70
40 - 60	8.2	5.9	3.2	0.24
60 - 80	15	9.0	5.0	0.32
80 - 100				0.46
100 - 120				0.47

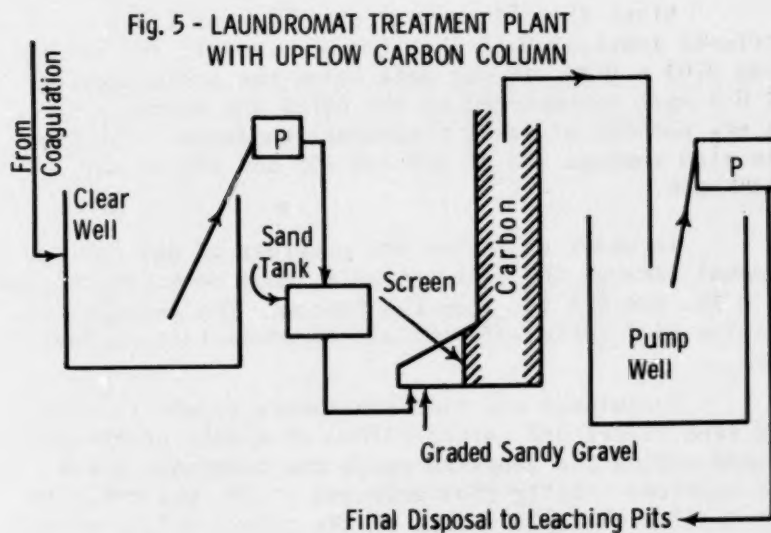
Note: The ABS of the coagulated and clarified waste applied to the filters in this experiment averaged 16 mg/L and ranged from 15 to 18 mg/L.

phase of the investigation (wood and bone). Activated carbon from coal appeared to be so superior to the other form that one small filter packed with coal carbon was superior to three of the others in series. This is shown in Table X. It appeared that activated carbon made from coal had both greater adsorptive efficiency and greater adsorptive capacity.

PERFORMANCE OF VILLAGE COIN-OP TREATMENT PLANT - FINAL PERIOD

Following the collapse of the gravity carbon filter described in phase I, a cylindrical pressure filter was constructed. It was 10 ft. deep, 2 ft. in diameter and held 600 - 900 lbs. of granular activated carbon.

The coagulated and clarified waste flowed by gravity to a clear well, and was then lifted by a $3/4$ H. P. pump through a small sand filter used primarily as a protective device for the carbon column which followed it. Exhausted carbon may be removed from the bottom of the upflow pressure filter, and replaced by fresh carbon at the top. Fig. 5 is a flow diagram of the unit starting with the clear well. The initial



stages of treatment were the same as previously described. (Coagulation was accomplished with 250 mg/L of alum and about 410 mg/L of lime.) The operation of the filter and of the entire process has been encouraging to date.

The average results of 14 series of samples taken over a 5 month period are summarized in Table XI.

Table XI. -- Performance of Laundromat Waste Treatment Plant
(October 1962 - March 1963)

	<u>No. of Samples</u>	<u>Raw Waste</u>	<u>Coag. and Clarified</u>	<u>Carbon Filter Effluent</u>
ABS	14	68	13	0.13
COD	14	491	152	70
BOD	14	184	43	24
Susp. Solids	11	206	43	16
Total Solids	2	880	1030	880
pH, (Median)	14	7.8	11.2	11.0
Total Alkalinity	14	167	225	178
Coliform (Range)	9	36-46x10 ⁶	3.6-24x10 ⁴	3.6-24x10 ³
Res. Alum (Range)	9	-	6 - 14	5 - 14
Phosphate	1	18	0.90	0.30

Since the ABS concentration in the final effluent averaged 0.13 mg/L (99.8% removal) and ranged from 0.03 - 0.32, it was well below the concentration of 0.5 mg/L recommended by the USPHS for drinking water, to say nothing of waste treatment standards. The process also removed 98% of BOD and COD and 98% of the phosphate.

In order to follow the progress of ABS and COD removal through the filter itself, taps were constructed at 2 ft. and 4.5 ft. from the bottom. The average results of 7 series of samples are summarized in Table XII.

Coagulated and clarified waste flowed through the sand filter and carbon column at a rate of about 20 GPM during the hours in which the treatment plant was operated. Daily flow averaged 14,000 gallons. It was decided to replace some of the carbon column when

Table XII. -- Performance Profile of Village Coin-Op
Pressure Carbon Filter
(Dec. 1962 - March 1963)

	<u>ABS</u>	<u>COD</u>
As applied to filter bottom	9.7	143
at 2 ft. level	5.2	133
at 4.5 ft. level	1.8	88
Final Effluent	0.1	68

the effluent ABS exceeded 0.5 mg/L, a condition which had not occurred in the first 5 months of operation. Actually some carbon was added on only 2 occasions primarily to practice the technique of replenishment.

The following cost analysis was based almost exclusively on expenses and estimates of the owner of Village Coin-Op Laundromat.

Average Daily Flow = 14,000 gallons
Maximum " " = 20,000 "

Laundry open 12 hours daily, 6 days a week	
Chemical cost per week, including carbon	\$18.00
Maintenance cost per week, 10 hrs. at \$2.75	27.50
Depreciation of treatment plant	<u>40.00</u>
	\$85.50

At 1800 washes per week, the cost per wash was

Chemicals	\$0.01
Maintenance	.015
* Depreciation	<u>.022</u>
Total	\$0.047 per wash

* \$10,000 original cost amortized over 5 years.

DESIGN RECOMMENDATIONS

1. The treatment unit should be as compact as possible. Space is normally at a premium.
2. Two 5 ft. carbon filters in series might be more practical and less cumbersome than one tall 10 ft. filter. When the final effluent from the second filter exceeds a certain predetermined value, the carbon in the first filter should be replaced and the direction of flow reversed.
3. Pitt Carbon, 8 x 30 mesh, or its equivalent, is recommended.
4. The raw waste should be screened before its entry into the surge tank.
5. It is recommended that surge tank volume be 50% of the maximum daily flow.
6. A circular clarifier should be designed for upflow through the sludge blanket.
7. The treatment plant should be designed for a flow of 20 GPM for the average laundromat.

CONCLUSIONS

1. Over 80% of the ABS and 78% of the COD can be removed from laundromat wastes by flocculation with alum at low pH (4.3 - 4.6) or with alum and lime at high pH (11.3 - 11.4).
2. Alum flocculation resulted in BOD reductions of 75 - 85%.
3. Flocculation with alum and lime at a high pH produced a rapidly settling sludge and permitted much higher overflow rates in the clarifier than was possible with alum flocculation at low pH values.

4. Final filtration through granular activated carbon resulted in almost complete removal of ABS and 85 - 90% removal of COD and BOD.
5. Coagulation and clarification at high pH also removed 95 - 98% of the phosphates.
6. Filtration of the coagulated and clarified liquor through granular activated carbon proved much more effective, economical, and convenient than addition of powdered carbon with the coagulating chemicals.
7. Over 5 months of actual operation in a laundromat showed that this process is both feasible and dependable.
8. There was a marked difference in the efficiency and capacity of the various carbons used. Pitt Carbon, 8 x 30 mesh, showed the best results. This carbon can also be regenerated and reused.
9. Further studies should be made to determine if a final pH of 9 could be effected.
10. Future studies should also include consideration of reuse of the water in the treated waste effluent.

* * * * *

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